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Cardiff Post Office Simulation

Group 18
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Data Collection and Analysis

Statement of objectives

Introduction

Our group was assigned the task of simulating a system of our choice using Simul8. Our approach reflects a queuing system within a post office in the City Centre in Cardiff. We collected real-life data to reflect real-life conditions to ensure that our model is designed based on how the post office operates. We collected a range of actual data, including service times and inter-arrival times. This model will evaluate the time clients spend in the post office, their average and maximum waiting times for different activities, and discover the utilisation of the other services. This information has been utilised to inform decisions to improve both client satisfaction and business operations.

Model Aims

- To model the customer queuing system of a high-street post office in Cardiff city centre on a weekday between the hours of 09:00-17:50 (8.5 hours)
- To reduce the average waiting time and maximum waiting time in the queues by discovering optimal resource values (number of staff or machines)
- To discover the amount of utilisation for the staff as well as the machines within the post office.

Data collection methods

We chose to collect data by going to the post office and manually monitoring a range of activities to inform our model. We managed a range of data points; these are the combination of inter-arrival times, service times, resource values (number of staff), and customer behaviour and activities. We used an excel spreadsheet to collate the data and used this data to inform our model parameters. We collected data on customer activity, whether they chose to see a staff member or shop clerk or instead used an automated system that does not require human interaction. Our method of data collection was observation. Group members went to the Cardiff post office and monitored an average day to gather actual representative data. Exactly what each of these data points was and how they were measured is outlined below.

Our data and model parameters

Variable definitions and details on how they were measured

Inter-arrival times

- The time of arrival for a unique customer entering the post office; measured as HH: MM
- The time of exit for that same customer leaving the post office; measured as HH: MM

Service times

- Initial waiting time a unique customer had to wait before seeing a shop clerk or using an automated machine; measured in seconds.
- The amount of time for each given activity, the activities include:
    - Money orders at the currency exchange; measured in minutes
    - Parcel collection or returns; measured in minutes
    - Letter collection or sending; measured in minutes
    - Use of ATM or automated top-up machines; measured in minutes.

Resource values

- The number of staff working during the shift, measured as an integer.

Customer behaviour

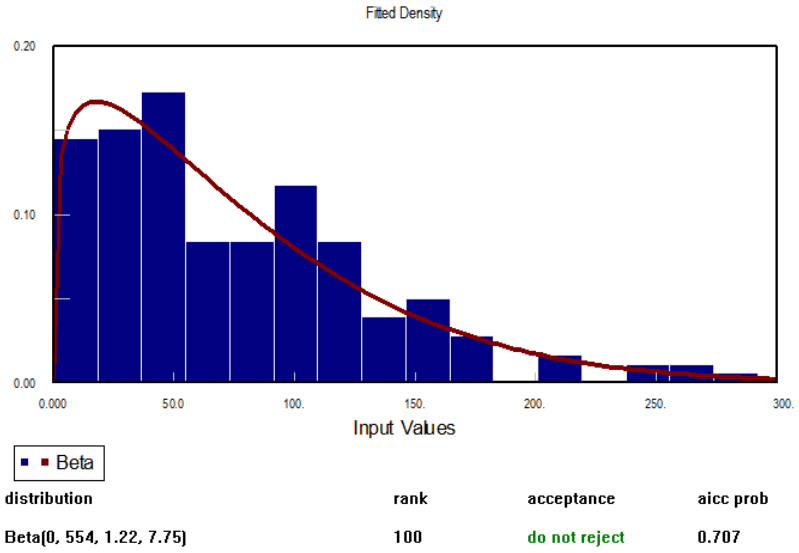
- Whether or not a given customer visited both the automated machines and the shop clerks in the same visit, measured as a binary value.

How the data collected influenced the model parameters.

We used the additional "Stat::Fit" plugin within Simul8 to discover the distribution of a range of parameters. We used these distributions to represent the inter-arrival and operation times within the model. Additionally, we performed some basic manual calculations to discover additional parameters such as the routing-out options in the model, as described later.

Inter-arrival times

We observed a total of 180 customers during our data collection period. We discovered that the trend for arrival rate followed a Beta distribution, with values of (0, 554, 1.22, 7.75) – as shown in figure 1.

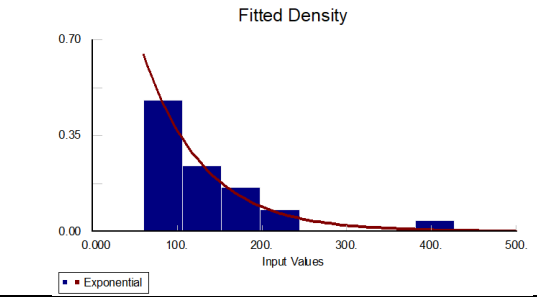
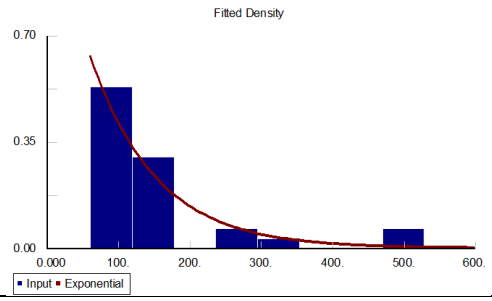


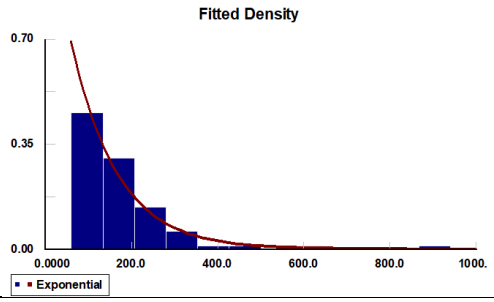
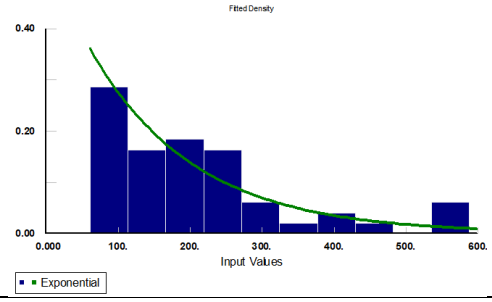
distribution	rank	acceptance	aicc prob
Beta(0, 554, 1.22, 7.75)	100	do not reject	0.707

Figure 1: Beta distribution of the inter-arrival rate for unique customers visiting the post office during our observation period.

Service times

We found several different distributions when each customer waited to use each of the post offices activities for the service times. Additionally, we calculated a mean average of customer wait time based on the wait time of all customers before they began acting in the post office. This value was an average of 67 seconds.

Letters	Parcels
	
Exponential distribution for service time when a customer visits the letters counter.	Exponential distribution for service time when a customer visits the parcel counter.

Money	Machines
	
Exponential distribution for service time when a customer visits the money counter.	Exponential distribution for service time when a customer visits the machines.

Summary of service time distributions

Operation	***Fitted distribution***
Inter-arrival time	Beta (0, 554, 1.22, 7.75)
Wait time	Average (67) seconds
Machine server time	Exponential (207) seconds
Money order time	Exponential (166) seconds
Parcel time	Exponential (153) seconds
Letter time	Exponential (131) seconds

These distributions can be directly plugged into our model in simul8 as parameters for the service time for the corresponding activity.

Resource values

On the days we collected data, we observed five staff split between the different activities acting as clerks for the customers and two separate machines that were available for customer use. This information will allow us to adjust the resource values in simul8 to match what the real-world scenario shows.

Customer behaviour

According to our observations, 80% of the customers who entered the post office went to a manual counter with a human assistant, whereas the other 20% used automated machine servers. Additionally, we found that 24.5% of the people who use the machine then go back and see a clerk; furthermore, 7.1% of the people who visit a clerk then use an automated machine server. This information was found by labelling customer records with a binary value to indicate if they used both types of activity during the collection. This information will be used to simulate the routing of entities

in the model based on these percentages. Of those customers who went to visit a shop assistant or clerk, there was the further insight we could gain from our data to inform our model parameters, such as:

Of those customers who went to see a clerk, we can deduce percentages of what service they required.

- Picked money order counter – 50%
- Picked letters counter – 22.5%
- Picked parcels counter – 27.5%

Simulation Model

Description of our model & model functionality

The system we created represents the journey of a customer walking into the Cardiff post office, choosing one of the services to attend, and exiting the system. The system always assumes that a customer uses the facilities and that no one ever leaves the queue whilst they are in the queue. This follows from our observations whereby no customers left the shop unless they had used a facility.

There is only one way to arrive at the shop, and thus there is only one starting point in the model. The arrival rate is decided by the inter-arrival distribution, as shown in figure 1. From here, 80% of the customer's head to a shop assistant for their services, whereas 20% use automated machines. Those who went to see a shop assistant are distributed 50%, 22.5% & 27.5% for the various counters, money counter, letters counter, and parcels counter, respectively.

The manual counters with clerks each have a different distribution for the number of activities in these areas, as shown above. These distributions are applied to the model. There are two clerks for the money order counter, two clerks for parcels, and only one working at the letter desk. These are also added to the model's parameters.

For the machines, an exponential distribution is used to decide the activity time.

Furthermore, once customers have gone to either the machine or a human shop assistant, there is a chance they will then use the other activity. These values must be added to the model.

Finally, the customers leave the shop, and that correlates to the entities leaving the model. There is no wait time to leave the shop.

We use the resource functionality to assign staff to their respective activities. One staff member can only perform one task at a time, and they must complete their task before starting another.

N.B. There are no travel times accounted for in this model as they are negligible in the real-world example.

The Simul8 model

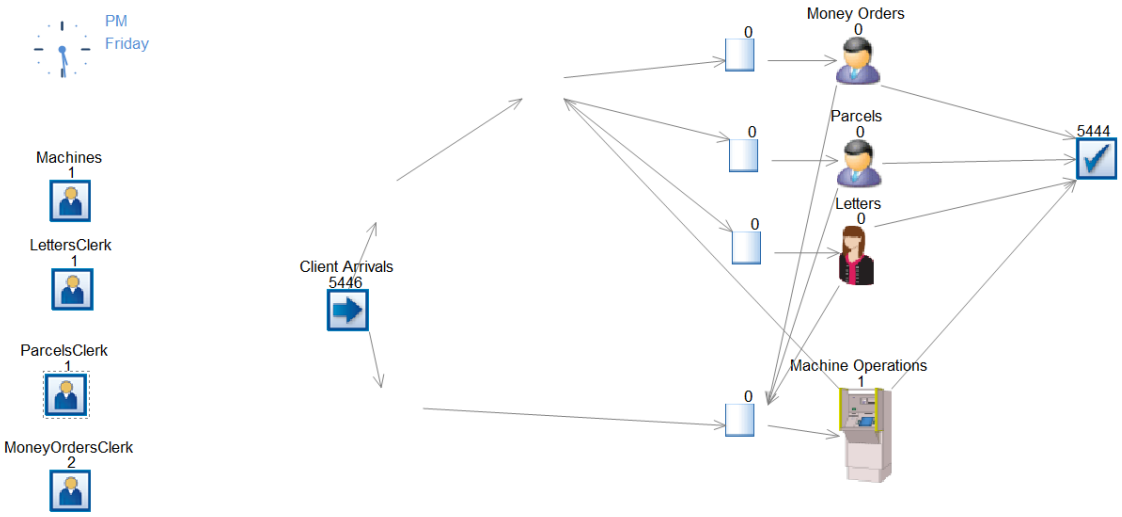


Figure 2: Figure 3: Screenshot of the model developed in Simul8

Model processes

- The three human icons on the right of figure 2 represent where a clerk oversees the labelled activity above the icon; this is where customers will partake in their transaction. Underneath is the automated machine, which does not require a human to oversee; however, there are two of these. On the left are the available resources that we can tweak to adjust the number of shop assistants/ clerks and the number of machines available.
- The overall process for a customer is to:
    - Enter the system
    - Join a queue that represents what they need to do (either manual or automatic)
        - If manual:
            - Letter counter
            - Parcel counter
            - Money exchange counter
        - If automatic:
            - Machine operation
    - Complete their respective activity
    - Either choose to leave the system or stay in the queue again for the another activity

Experiments and Results

Description of running our model (trials and scenarios)

In order to get results from our model, we need to conduct a series of trials. To know how many trials we wanted to complete, we used the trial calculator in Simul8; figure 3. The parameters for the required results are based on the original model's aim, whereby we want accurate results depending on the average/ maximum time in the system and service utilisation. The calculator suggested using 26 trial runs to gather results. Each trial is the model being run through the period of the whole day (30600 seconds). The results from each trial are averaged between a 95-percentile range. By doing so, we can see the effect of the model with our collected data to perform some analysis.

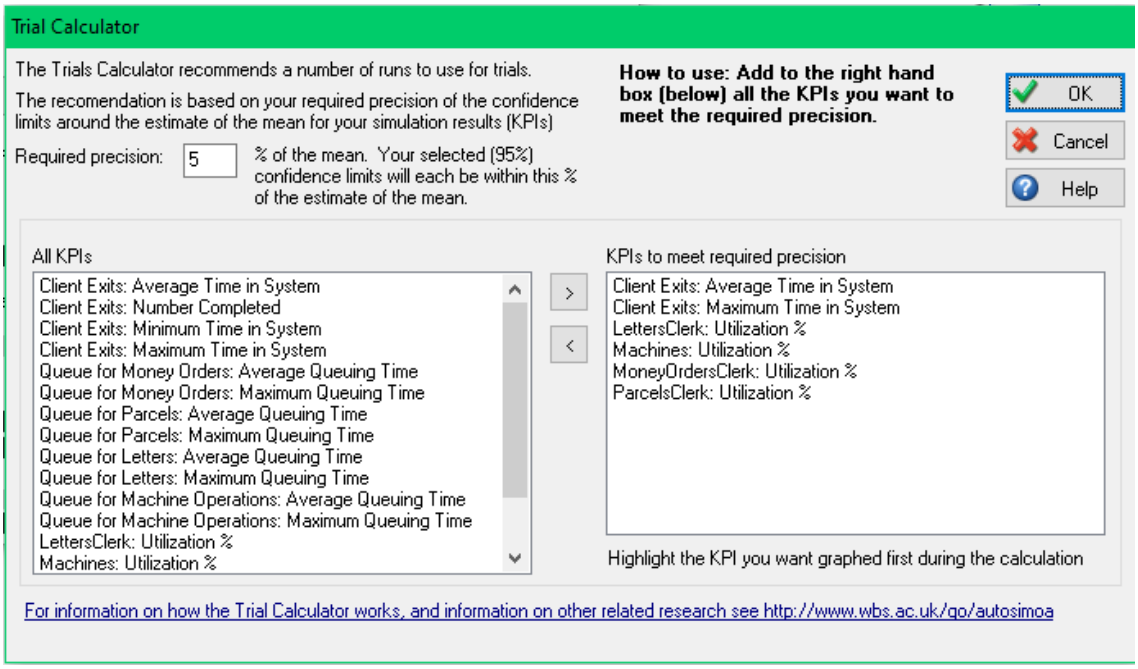


Figure 4: Trial calculator for our model, to get a recommended number of trials to achieve our required precision of 95% for our required KPIs.

Results

Once we then performed our trials, we gained insight via the results manager which gave us these readings, as follows:

	Results	Low 95% | AVERAGE | High 95%		
Client Exits	Average Time in System	264.43	265.93	267.44
Client Exits	Number Completed	5390.15	5403.42	5416.70
Client Exits	Minimum Time in System	0.23	0.32	0.42
Client Exits	Maximum Time in System	1949.41	2050.59	2151.77
Queue for Money Orders	Average Queuing Time	7.85	8.47	9.09
Queue for Money Orders	Maximum Queuing Time	508.43	577.09	645.75
Queue for Parcels	Average Queuing Time	49.67	52.83	55.99
Queue for Parcels	Maximum Queuing Time	1046.31	1161.23	1276.15
Queue for Letters	Average Queuing Time	24.55	25.90	27.24
Queue for Letters	Maximum Queuing Time	771.68	864.11	956.54
Queue for Machine Operations	Average Queuing Time	13.38	15.18	16.98
Queue for Machine Operations	Maximum Queuing Time	667.49	781.24	894.98
LettersClerk	Utilization %	22.27	22.57	22.86
Machines	Utilization %	23.45	23.81	24.18
MoneyOrdersClerk	Utilization %	31.00	31.30	31.60
ParcelsClerk	Utilization %	31.78	32.34	32.90

We can see here that a given client spends an average of 265 seconds in the system and therefore in the post office. They mostly wait at the parcel's operations queue, on average, for 53 seconds. According to the results, manual operation clerks is not preferred most times, and their engagement is ranged from 22.57% to 32.34%. In contrast, the machines are mostly preferred at an average of 31.30%.

Key findings

Post office management should see from these findings that they should switch their current infrastructure to a standard counter that provides all required activities rather than separate tills. There will be the need for retraining and possible equipment expenses. However, these changes should increase overall efficiency and reduce waiting time, resulting in a more significant money turnaround. By banding the activities together under a standard counter, the utilisation rate would dramatically increase, beneficial to both the customers and the post office itself. Another suggestion might be to build a first in, first out queuing system to be fair to all customers whereby their arrival time dictates when they are served and not the service they require.